AIR WAR COLLEGE

AIR UNIVERSITY

# WHAT IS AN AFFORDABLE STRATEGY FOR RECAPITALIZING THE AIR FORCE OF THE FUTURE?

Thesis: Significant savings can be realized by procuring stealth capable platforms as opposed to having full stealth features without overall loss of mission capability.



by

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# Biography

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# Introduction

This research project will focus on the affordability of the weapon systems the Air Force procures. Specifically, the research will focus on the feasibility to save money by looking at the life cycle costs of a major weapon system. The question I will try to answer with my research is: What are the potential cost savings to be realized by procuring stealth capable platforms on an as-needed basis, as opposed to having full stealth features all of the time? My thesis statement is: Significant savings can be realized by procuring stealth capable platforms as opposed to having full stealth, without overall loss of mission capability.

Unfortunately, the term stealth is more commonly used than defined. It has become part of the vernacular and has evolved to describe anything which is unclear or hidden. It no longer describes the military applications as originally intended. The term 'Low Observable' is more commonly and correctly used to describe platforms having stealth characteristics and therefore this research paper will use the term Low Observable (LO) to describe stealth technology. MIL-HDBK-513A defines Low Observable (LO) as "an organized discipline that works to manage the radar cross section (RCS), Infrared (IR) signature, visual signature, acoustic signature, and control the electronic emissions of air vehicles for the purpose of reducing adversary detection capability to decrease susceptibility."[1]

The various types of LO deal with the frequency band they work in. There are: Acoustic LO, Infrared LO, Visual LO, and Electromagnetic (Radar) LO. This research will concentrate on the radar LO.

Several characteristics define platforms employing LO technology. In the realm of radar, the goal of any LO platform is to reduce the radar cross section (RCS) of the platform. LO

aircraft achieve the reduction of their RCS by employing several techniques. The external geometries of LO aircraft are redesigned. An LO aircraft will have curved or nearly flat angle surfaces to either absorb or deflect the radar energy. LO aircraft make use of composite material as much as possible. Composite material typically will not reflect radar energy, but will allow it to pass thru the composite material. All mating surfaces or seams will employ a technique called faceting. The mating surfaces in a non-LO aircraft are straight line joints. In a LO aircraft the design is to employ angled or irregular shaped mating surfaces. It can be visualized as a saw tooth mating surface. Finally, LO aircraft are coated with radar absorbent material (RAM). This RAM will absorb or deflect the radar energy thereby reducing the aircraft's RCS.[2] In addition, this reduction of the aircraft's RCS thru these various techniques allows the aircraft's electronic counter measures (ECM) to become more effective. If only a small amount of radar energy is reflected back (reduced RCS), the ECM energy required to jam or spoof the tracking radar is greatly reduced.[3]

Few aircraft can be made with composites alone, and therefore will need to be coated with RAM material to maintain their LO characteristics. Composites are being used more often as the composites mature and are able to withstand larger stress loads. However, in fighter aircraft the stress loads encountered far exceed the composite material ability to endure those stresses. For this reason composite material will be limited in their application in fighter aircraft, and these types of aircraft will continue to rely on RAM to provide their LO characteristics along with geometries, and faceting of the aircraft.[4]

## Narrowing the Focus

The Low Observable (LO) technology application is a large and diverse area. Therefore this research will need to narrow the focus by exploring a specific platform to be researched, the

specific LO features producing the greatest cost savings, and the associated mission requirements. The research will look to explore specific cost savings by focusing on the manufacture of future aircraft that are LO capable rather than fully LO compliant. By exploring cost savings on aircraft, it is understood there may be significant cost savings which may be applied to other platforms.

The application of LO technology can be thought of as: structures, structures, structures, and materials. As indicated in my introduction, this research explored the various structures defining the LO technology, removal of straight lines, no flat surfaces, use of composite material, and application of radar absorbent material (RAM) to the exterior of the platform. Changing the structure of the aircraft would not be cost effective. Therefore, this leaves the application of RAM material. The RAM is applied to the skin of the aircraft, much like aircraft paint would be. The RAM material is costly, much more so than regular aircraft paint. I will explore the applicable cost savings of using aircraft paint as opposed to applying RAM material to the aircraft during production.



There are several aircraft (i.e. F-117, B-2, F-22, F-35) employing LO technology. In addition, it is rumored the new Long Range Strategic Bomber (LRSB) will incorporate LO technology. There are other platforms rumored to employ LO technology, however I will focus on aircraft for my research with the understanding any solutions may be applied to other platforms.

Considering the mission requirements of the various aircraft employing LO technology will narrow the field of research down further. Aircraft required to be ready to deploy at a moment's notice will be required to be fully LO compliant at all times. Bomber aircraft are part of the nuclear triad. Bomber aircraft that are nuclear certified are required to be on alert status

and ready to take off within a relatively short (minutes to hours) take-off window. Therefore, having bomber aircraft without their intended component of LO capability would negatively affect their ability to perform their mission. Therefore, this narrows the research possibilities to fighter aircraft.

To maximize cost savings, this research will focus on aircraft currently in the acquisition cycle allowing for cost savings determination thru the acquisition life cycle. It will focus on the costs associated with procurement, maintenance (both organizational and depot level), sustainment, and basing. This will focus the research on the F-35, Joint Strike Fighter, as it is the only LO aircraft currently in the early stages of procurement.

Therefore considering all the above factors, I will explore procuring the F-35 with all the structural features of LO but without the RAM applied, and just using normal fighter aircraft painting processes. This research will include: researching the material, labor, and testing costs associated with procuring the F-35 with RAM applied, researching the materials, labor, and testing costs of a similarly configured aircraft and determining if there are significant savings to be realized.

## Mission Requirements

It is important to factor in mission requirements when proposing saving costs on procurement. Therefore this research will look at the current and future mission requirements of LO aircraft and factor these against the potential savings to determine viability. This research will examine three levels of mission sets: peacetime, limited conflicts, and full wartime requirements.

### Peacetime

Consider the situation where the United States does not have a conflict for the next 30 plus years. In this scenario, it is self-evident fighter aircraft in peacetime environments are not required to be low observable. Currently, non-LO fighter aircraft (F-15, F-16) operate without LO capability. The lack of LO characteristics does not affect the aircraft's aerodynamics. However the geometries of LO aircraft (F-117, F-22) provide several of the characteristics needed for LO, adversely affecting the aerodynamics of these jets. The F-117 was so aerodynamically unsound it required computers to control it, or otherwise it would crash. Many of its pilots unofficially called it the "wobbly goblin".

As stated previously, in describing LO aircraft the overall guiding principle is structure, structure, structure, and materials. The proposed goal of this research is to save costs by adding on those LO features, where feasible, when and then only if required. The application of RAM material on an as required basis meets this requirement.

There is a caveat to the peacetime scenario. The recognition there would need to be several F-35 aircraft training squadrons required to have full LO features to include RAM material. These training squadrons would be used to train pilots on the full LO capability of the aircraft. Currently, most F-22 pilot training is centered around flying the aircraft and dropping bombs on targets. Very little of the training is based upon the LO features of the aircraft. This LO training could be accomplished at special squadrons equipped with full LO capable aircraft.

Fighter aircraft are required to be LO in combat against an adversary. There is no need or requirement for fighter aircraft to be LO during peacetime. Spending money to procure the F-35 with RAM material for the aircraft to operate for 30 plus years, while never seeing combat would be financially unsound. In addition the costs to maintain the LO material over the life of the aircraft further increases these costs.

Limited Conflicts

Most of our recent wars have been limited in scope. There has not been a full mobilization of the county and all of the country's assets since World War II. A recent example of the limited conflicts of the sort the US currently engages in is the invasion of Iraq in 2003. Unfortunately, a limited conflict can crop up at any time. Therefore, there must be a quick reaction capability that is fully LO equiped.

This research recognizes the requirement to have a limited number of fighter aircraft with full LO capability ready to deploy quickly. The proposal would be to have several squadrons of full LO capable F-35s ready to deploy at a moment's notice. This would mirror the first Iraq war where F-117 stealth fighters were tasked with high risk targets. The rest of the fighter aircraft followed in after the high threat targets had been neutralized. The correct numbers of aircraft would comprise an immediate response capability and locations of these squadrons could be further developed at a later time, and therefore is not part of this research. In addition, these aircraft would comprise the peacetime training requirement discussed earlier.

Full wartime requirements

The value of full LO capability would not be realized unless the US was engaged in a state on state conflict with a near peer adversary. Only then would the full fleet of F-35s be required to have full LO capability. It has been over seventy years since the last full scale war. During the run up to any major conflict there has been time to mobilize the country and the required forces. This would be true of the requirement for full LO F-35s. The aircraft would be manufactured with all the required structural elements of LO except without the RAM material applied. The F-35s would be painted with normal aircraft paint which is required for corrosion protection. The aircraft could look as if they had the full LO capability and only would be

discernable from the LO aircraft by their tail numbers, this would add an element of camouflage to the fleet of aircraft.

During the advent of a full conflict where all F-35s would require full LO features to include RAM material, there is typically a time frame where mobilization of the nation's forces happens. During this time frame the F-35s requiring the LO application would be processed thru the RAM material application process. This would require several facilities be kept at the ready to process the F-35 to add the required RAM material. Ideally, such facilities would exist at the major logistic depots and facilities at the current contractors who manufacture the F-35. These F-35 LO application facilities could be kept open for the life span of the aircraft. The application of the LO RAM material is a very complex, highly skilled process. The concern would be if these facilities remained idle then the skills of the labor force and the process controls would deteriorate over time. This could be minimized by the previously discussed small fleet of full LO compliant aircraft being transitioned thru these facilities during their normal depot maintenance cycles. If full mobilization ever happened, the fleet of F-35s would be processed thru the LO RAM application facilities in a relatively short time frame.

The application of LO RAM material only when needed as in the advent of full conflict has an added advantage. It has been demonstrated with current and past LO aircraft that the LO RAM material degrades with time, weather, and handling and use. There is a constant maintenance and testing cycle regarding the LO condition of each aircraft and its corresponding mission capability requirement. The maintenance and testing area will be discussed in further detail in the maintenance section of this paper.

In summary, full LO capability is not required in peacetime with the exception of a relatively small number of aircraft required for a rapid strike capability. The LO RAM material

would only be required on the entire fleet of aircraft in the case of full war. The cost savings during procurement is significant. In addition, there is cost saving during the life of the aircraft which could be substantial. Every maintenance action not required to fix the RAM material and the subsequent testing over the life of the aircraft can add up to substantial savings.

## Cost Comparison

In focusing on the affordability of the F-35, Joint Strike Fighter (JSF), it will be necessary to compare costs of its current configuration against the proposed configuration (minus the RAM material). The current configuration of the F-35 with full LO capabilities is approximately $160 million per aircraft.[5] This research will determine the feasibility of procuring the F-35 without one key component of the LO structure – the radar absorbent material (RAM). This concept was explained in greater detail elsewhere in this paper.

My methodology for determining the potential saving is through a cost determination. My proposal will determine the costs associated with the application of RAM, which entails an analysis of the costs of the RAM material itself, versus the costs to simply paint an aircraft. The F-35 receives a top coat which is applied on top of the LO material. The top coat is similar to the top coat of paint applied to non-LO fighter aircraft. The costs to apply a top coat to the F-35 and paint a non-LO fighter are approximately equal. Therefore, the costs to apply the LO material, both material and labor costs, to the F-35 would be the savings per aircraft. Unfortunately, the actual cost data is considered proprietary and competition sensitive by the contactor, and was not able to be obtained as of the submission of this paper. However, if the LO material, labor, and associated testing costs added just one-tenth of a percent to the costs of the aircraft it would be a savings of approximately 160 thousand dollars per aircraft in procurement costs. With total procurement projected to be 2,440 aircraft, the total procurement savings would be significant.

In addition, I will attempt to quantify the associated maintenance costs associated with the upkeep and repair of the RAM material on the F-35. Specific special test equipment is required to continuously validate the LO characteristics of the RAM. Non-LO fighter aircraft do not have any of these special costs. If the F-35 was simply painted with aircraft paint the associated costs for the maintenance of the LO material would be zero. There are no testing costs associated with the routine painting process, therefore these costs would also be zero.

The costs to procure and apply the LO material is very expensive. The material costs and the labor costs to apply the LO material adds significant costs to each aircraft. In addition, there are special materials used to seal the various seams over the whole aircraft. A normal aircraft sealant material cannot be used. The labor hours and associated labor costs to prepare and apply the LO materials are significant. Specially trained mechanics are required to apply the various LO materials. In addition to the above material and labor costs, there are testing costs associated with ensuring the radar cross section (RCS) with within required specifications. The specialized test equipment costs are significant and unique to the F-35. In addition, specialized test facilities are required to perform a whole aircraft RCS test.

## Maintenance Costs

Maintenance actions on Low Observable (LO) aircraft are significantly different then non-LO aircraft specifically regarding the LO structures and materials associated with LO aircraft. The maintenance actions regarding the LO structures and materials of LO aircraft add significant costs to LO aircraft. MIL-HDBK-513A defines the LO Maintenance system as "the processes, materials, tools, and personnel used to identify defects in the LO AV subsystem, repair those that degrade its performance and ensure the AV meets LO mission requirements."[6]

Current LO aircraft (B-2, F-22) require special care and facilities to ensure damage and degradation to the materials comprising the skin of the aircraft are kept to a minimum. Current LO aircraft in the inventory are housed in enclosed facilities as opposed to being parked on the flight line out in the open as are current non-LO aircraft. This area will be defined further in the basing section of this paper.

The LO material comprising the skin of the F-35 aircraft requiring maintenance actions are typically more extensive than non-LO aircraft. Any nick, scratch, dent or ding is required to be tested to determine the effects to the radar cross section (RCS) of the aircraft. Any damage to the aircraft normally considered insignificant in a non-LO aircraft typically will have to be repaired as it affects the RCS. In a non-LO aircraft if the aircraft experiences a nick or scratch it would not require maintenance action unless it was exposing base material (metal or composite). Even then if it required repair the typical repair would be a localized repair by applying touch up paint.

For LO aircraft, special test equipment is required to test and categorize each nick or scratch. Anything affecting the RCS of the aircraft is required to be repaired. This specialized test equipment is required to be available at each operating location of the F-35. Following assessment of damage through testing, the LO RAM material must be repaired. Like other aspects of LO RAM, specialized high cost equipment is required to repair damaged LO RAM material. There are unique cure times and temperatures to be maintained when repairing LO RAM material. Even if the LO aircraft is located in an aircraft hangar, the environment may not be conducive to repair of the LO material. The F-35 would require this specialized test and repair equipment to repair its LO RAM material.

Maintenance actions requiring to be accomplished as the result of the degradation of the LO RAM material is another factor for consideration. The experience with the current LO aircraft (B-2, F-22) is the LO material degrades over time. Specifically, the characteristics making up LO RAM material degrade, and this degradation is accelerated by environmental conditions. The weather, especially strong sunlight, has a negative effect on LO material. Therefore, LO aircraft are not parked outside, or if they are on a temporary basis they are under some sort of canopy. This degradation of the LO material is required to be continuously checked and characterized against mission requirements. When the degradation reaches a certain point the aircraft is required to be completely refurbished with new LO RAM material or it becomes non-mission capable for aspects where LO would be required. Damage to LO material due to flying, aircraft handling, and maintenance to facilitate other maintenance (FOM) also need to be considered.

Finally, the major inspections required of all aircraft, to include the F-35, are periodically required to receive need to be considered when calculating the life time costs of having aircraft with LO RAM material installed. Aircraft are required to go thru several major types of inspections periodically. The isochronical inspection (ISO), or phased inspection, is typically accomplished at the airbase where the aircraft are located. The ISO is based upon number of flying hours and typically requires accomplishment of time change items, and the visual inspection of the aircraft for things like cracks and corrosion. The visual inspection normally requires the removal of various aircraft panels to access areas typically not looked at during normal aircraft operations. Each time aircraft panels are removed and reinstalled on LO aircraft the LO RAM material's integrity has been altered and must be restored. This application of new LO material and subsequent testing to ensure the radar cross section (RCS) is within required

parameters is very costly. The last major inspection requirement is the depot inspection. During an aircraft's normal life span, the aircraft may be subjected to a depot inspection every three to five years. Of course during the early years of an aircraft's life the major depot inspections are more spaced out. As an aircraft fleet ages and a history of problems is compiled, the inspection interval becomes shorter. Over the course of the lifespan of an aircraft, approximately thirty years, an aircraft may be subjected to six to ten depot level inspections. During a depot level inspection aircraft are typically stripped of their paint. This facilitates the removal of aircraft panels and allows a visual inspection of the exterior of the aircraft for cracks and corrosion. After the depot inspection is completed the aircraft is repainted. Considering the projected life span of the F-35 and the typical number of depot inspections it will have to go thru, there could be considerable cost savings by not having LO RAM material applied to the aircraft.

In conclusion, having the F-35 deployed without the LO material applied could result in significant cost saving by avoiding repair and reapplication of LO RAM material and subsequent testing arising each time a maintenance action disturbs the LO RAM material. Each time an aircraft panel is removed, each time a nick or scratch happens, each time a flight results in damage, each time environmental conditions degrade the LO material, each time an aircraft is stripped during depot inspections, the LO RAM material needs to repaired, reapplied, and retested. These costs could be avoided if the F-35 was procured and deployed without LO material and it was only added when really required during time of war.

## Basing Costs

Current LO aircraft (B-2, F-22) have unique basing requirements. Previously, fighter aircraft were typically parked on the ramp in their parking spots when they were not flying.

Maintenance was performed on the ramp. Preflight and post flight checks were performed on the ramp. Aircraft are launched from and are recovered to their parking spot on the ramp. Aircraft are subject to all types of weather conditions: hot, cold, rain, and snow. The only time the aircraft were brought in from the weather and put in a hanger was when a phased inspection needed to be performed which required removing panels from the aircraft. Of course if a major storm was predicted to hit the base, for example a hurricane, the aircraft would be flown to another base for safety. Some southern air force bases have taken to installing overhangs for parking fighter aircraft under to keep the intense sun from damaging them.

Current LO aircraft also have unique basing requirements. Because of the unique characteristics of the RAM material, LO aircraft are required to be hangered to prevent damage to the radar absorbent material (RAM) which comprises the skin of the aircraft. Damage to the RAM can be caused by various weather conditions, but the most damage to the RAM is caused by ultraviolet radiation, delivered by the sun. Most LO aircraft are parked in hangers to prevent damage caused by the sun and weather. This is a significant cost for LO aircraft as opposed to non-LO aircraft which can be parked on the ramp.

Basing requirements for the F-35 are currently expected to cost at 4.6 billion dollars.[7] There are unique basing requirements for the F-35 in order to keep it out of the weather and the sun to prevent damage. If the F-35 was painted with regular aircraft paint, there would be no need for unique basing requirements costing millions of dollars.

Previous history has shown the advent of a full war is not a rapid event. There is a period of time where hostilities escalate, and the country mobilizes for war. In the event of a full war, the aircraft without the LO RAM material would be processed thru the LO application process to add the LO material, just in time for when it is needed.

## Conclusion

In conclusion, significant savings are achievable by procuring LO capable platforms as opposed to having full LO, without loss of mission capability. Specifically, looking at the Joint Strike Fighter (JSF) F-35, significant savings are achievable by procuring F-35's without the radar absorbent material applied.

The F-35 is slated as the replacement for the F-16 and F-15 currently in the Air force's inventory. Neither of these aircraft are LO aircraft. If the F-35 is procured in sufficient numbers to replace these aircraft, the numbers of the F-35 required to be procured would be significant. Last numbers published states the AF plans to procure 2,443 F-35s.[8]

The up-front procurement dollars potentially to be saved is significant. The total savings in materials, labor, and testing costs is per aircraft is estimated to be substantial using a conservative one-tenth of one percent, and if 2,440 aircraft are to be procured by the AF the total program savings is estimated to significant procurement dollars. In addition, there is significant savings in maintenance dollars. The RAM material needs constant care and fixing especially if the aircraft are in severe weather or strong sun locations. The maintenance repair costs of the RAM material of the 30 plus years lifespan of the F-35 aircraft would be significant.

The mission requirements section of the research paper explored the various options for numbers and size of the F-35 fleet required. The mission requirements explored were options for a limited number of full LO compliant F-35 as a first strike capability, and to serve as a training fleet for aircrews and maintainers. The rest of the F-35 fleet would only require the application of the RAM material in the advent of a full mobilization. During full mobilization, cost considerations would take second place to having aircraft with full LO capabilities.

# ENDNOTES

[1]MIL-HDBK-513A, *Air Vehicle Low Observable Integrity Program General Guidelines*, DOD Handbook, 30 Sept 2010, p3

[2]Sweetman, Bill., *Stealth Aircraft*, Osceola, Wisconsin: Motorbooks Inc., 1986, p50

[3]Jones, J., *Stealth Technology – The Art of Black Magic*, Blue Ridge Summit, PA: TAB Books Inc., 1989, p37

[4]Jones, J., *Stealth Technology – The Art of Black Magic*, Blue Ridge Summit, PA: TAB Books Inc., 1989, p37

[5]US General Accounting Office (GAO) report, 15-364, F-35 Joint Strike Fighter, Assessment Needed to Address Affordability Challenges, April 2015, p5

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[7]US General Accounting Office (GAO) report, 15-364, F-35 Joint Strike Fighter, Assessment Needed to Address Affordability Challenges, April 2015, p5

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